CoRoT and *Kepler* observations of classical pulsators.
I. The vanishing of the Blazhko effect of RR Lyr
II. The pulsational content of Classical Cepheids

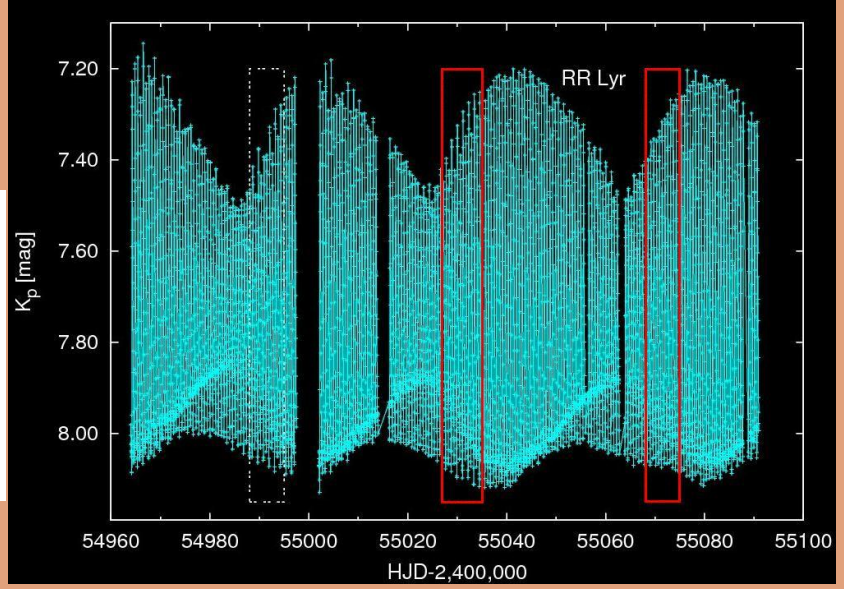
E. Poretti[1,2,3,4], J.F. Le Borgne[2,3,4], A. Klotz [2,3,4]
the CoRoT RR Lyr group,
the Kepler WG on RR Lyr stars,
and the GEOS observers.

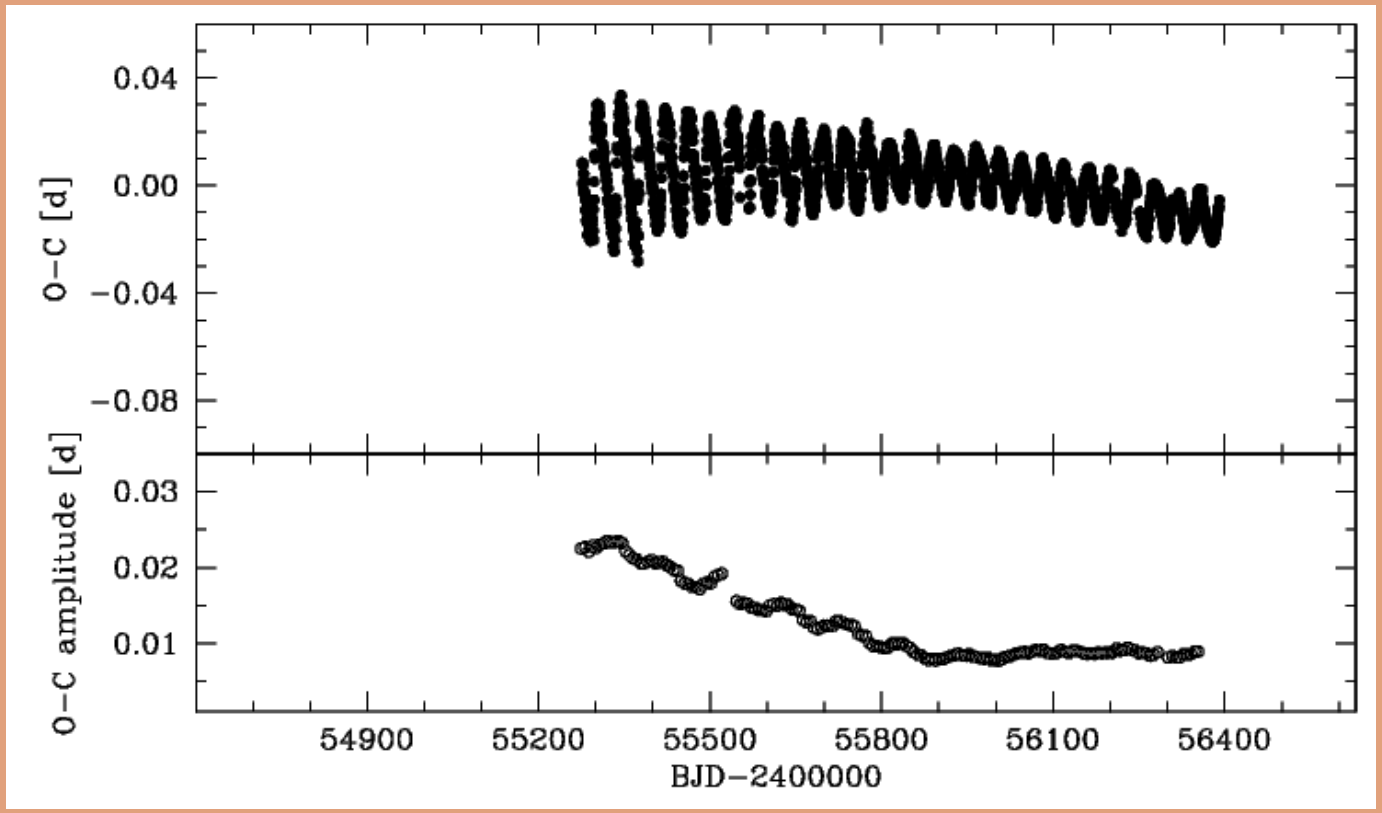
[1] *INAF-OA Brera*
[2] *Université de Toulouse, UPS-OMP, IRAP , Toulouse*
[3] *CNRS; IRAP, Toulouse*
[4] *Group Européen d'Observations Stellaires*

Kepler MILESTONES ON RR LYR

Kolenberg et al. 2011: half-integer frequencies related to period doubling

Molnar et al. 2012: three radial modes in RR Lyr. Period doubling onnipresent





Changes in the Blazhko effect reported by Several authors. E.g., *Stellingwerf, Nemec, Moskalik 2013*

RR Lyr was discovered on photographic plates of the *Henry Draper Memorial* by Mrs. Williamina P. Fleming in 1899. First observation: July 20, 1899

Observed with all techniques from ground : visual, photographic, CCD, spectrophotometry. Now, also from space with *Kepler*.

3975 maxima collected in the GEOS RR Lyr database, maintained by Jean-Francois Le Borgne at IRAP in Toulouse
The maxima span 114 years.

Today is Thu Jul 3 23:04:03 CEST 2014 JD 2456842.3778125

http://rr-lyr.irap.omp.eu/dbrr/

GEOS RR-Lyr database

The **GEOS RR Lyr database** is intended to help observations and studies on RR Lyr stars. It contains times of light maximum of RR Lyr stars obtained either visually or with electronic devices or photographically. The stars concerned are field RRab and RRc. The observations are collected in the litterature or submitted by observers. It presently contents some 60000 maxima on more than 3500 stars.
Delta Sct/SX Phe stars (formerly RRs) are not included in the database since they do not have the same evolutionary status. RR Lyraes in globular clusters would not be neglected, but it is another job ...

Access to data:

- **Introduction**
- **Complete list of stars**
- **Access by constellation and GCVS names**
- **Access by coordinates**

Date of last updates

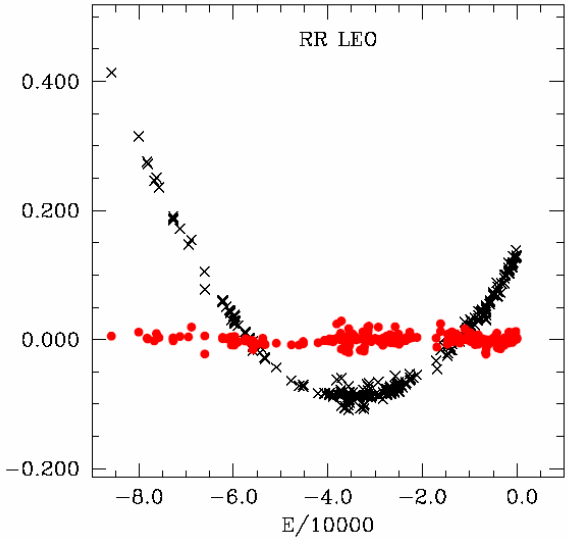
Element table:	2014-07-03 16:33:29	
General RR Lyr catalog:	2014-07-01 14:39:19	(18900 entries)
Maximum table:	2014-07-03 16:36:46	

83696 maximums on **15625** stars

Mirror diameter : 25 cm
field of view: 1.86°x1.86°
Pointing and instrument setting: 3 s
Maximum speed in pointing: 120 deg/s
CCD:
Marconi 42-40 thin back illuminated
Number of pixels: 2048 x 2048
pixel size 13.5µm = 3.3"
Readout time 5 s
Readout noise 8.5 e-

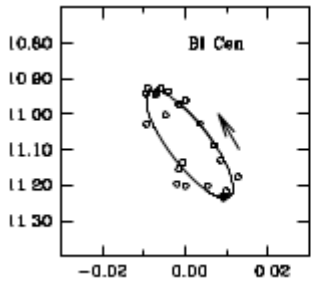
GEOS RR Lyr All-Sky Survey: automated observations with TAROTs

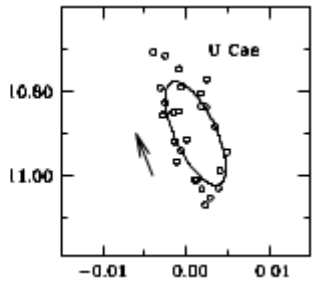
(Calern and La Silla)



EVOLUTIONARY CHANGES OF PERIODS
Le Borgne et al. 2007, A&A 476, 307

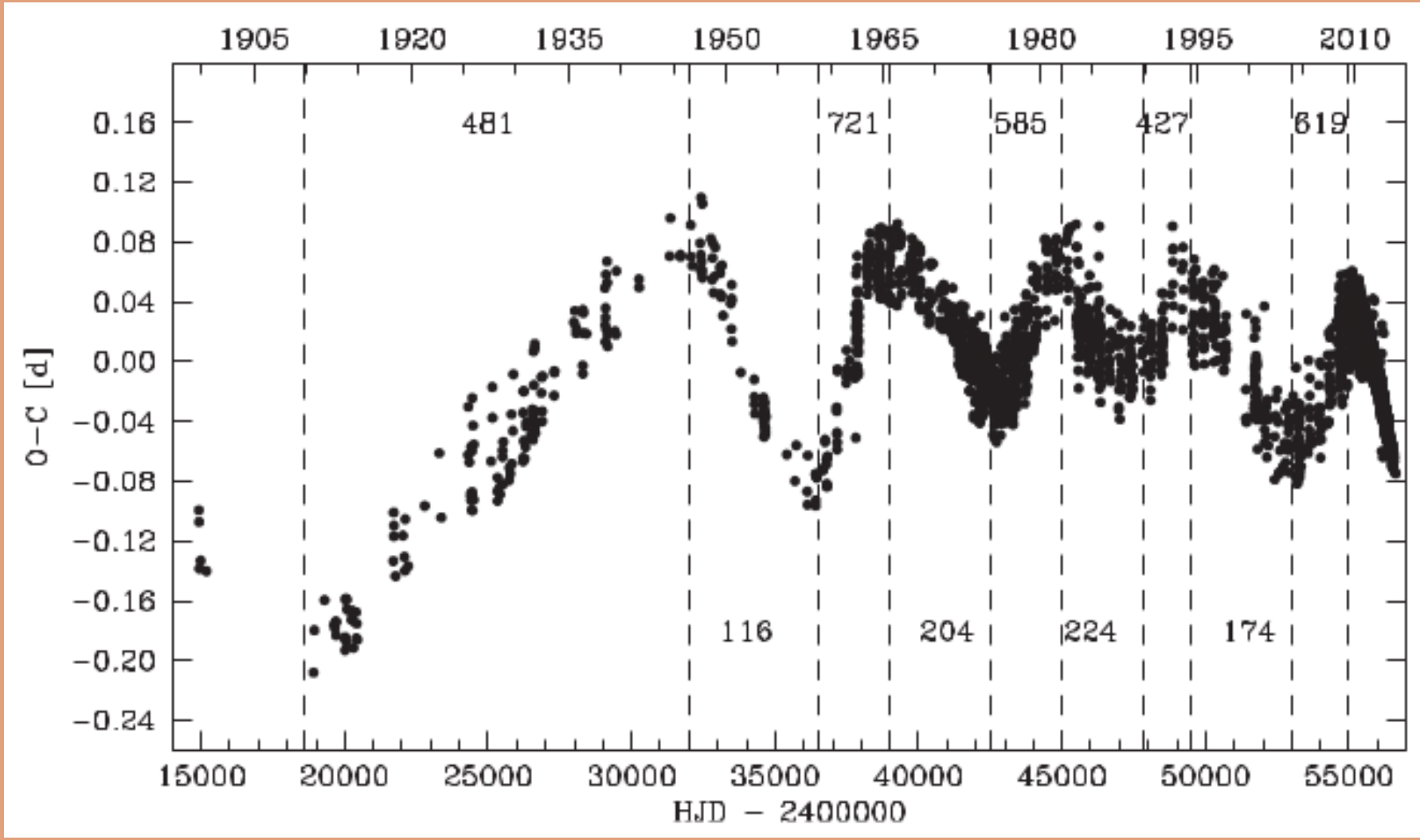
SHAPES OF THE BLAZHKO CYCLES
Le Borgne et al. 2012,AJ 144,39



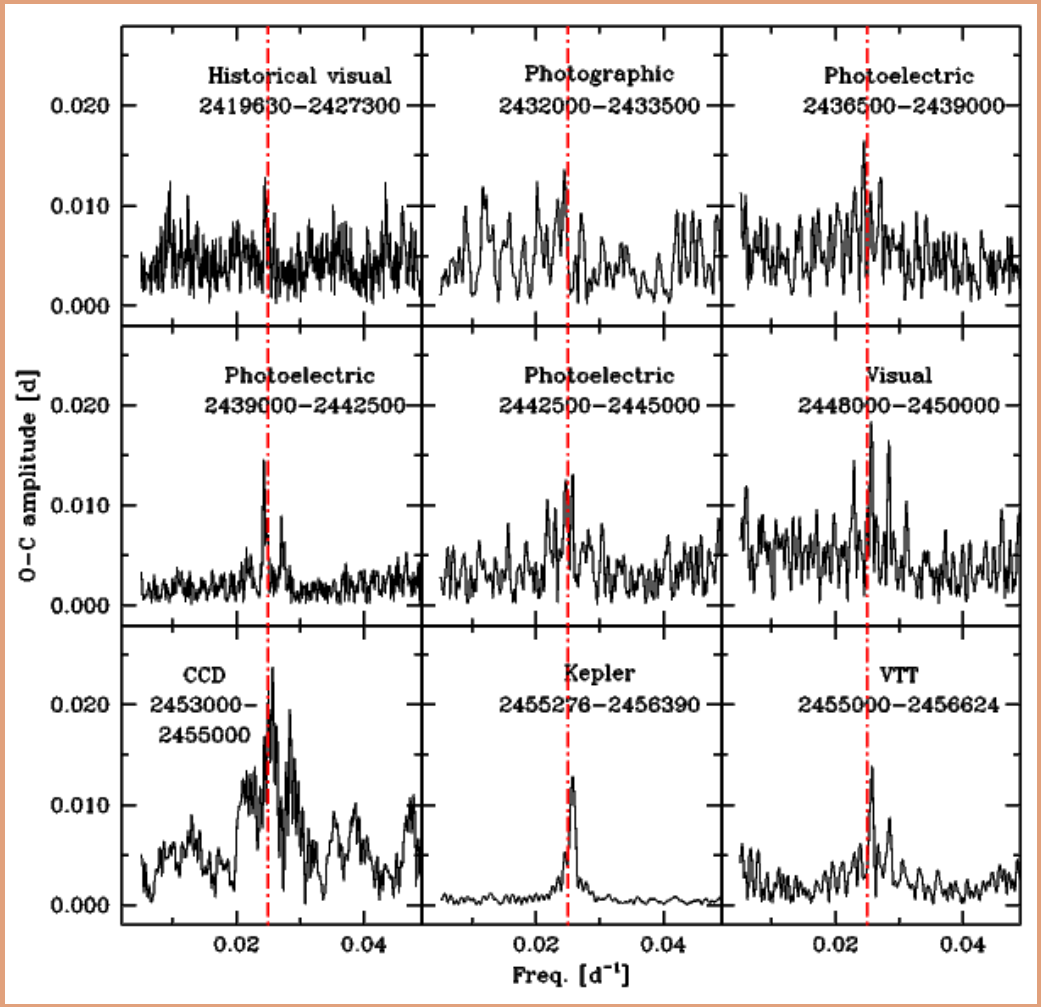


So, let's use the 3975 maxima of the GEOS database …

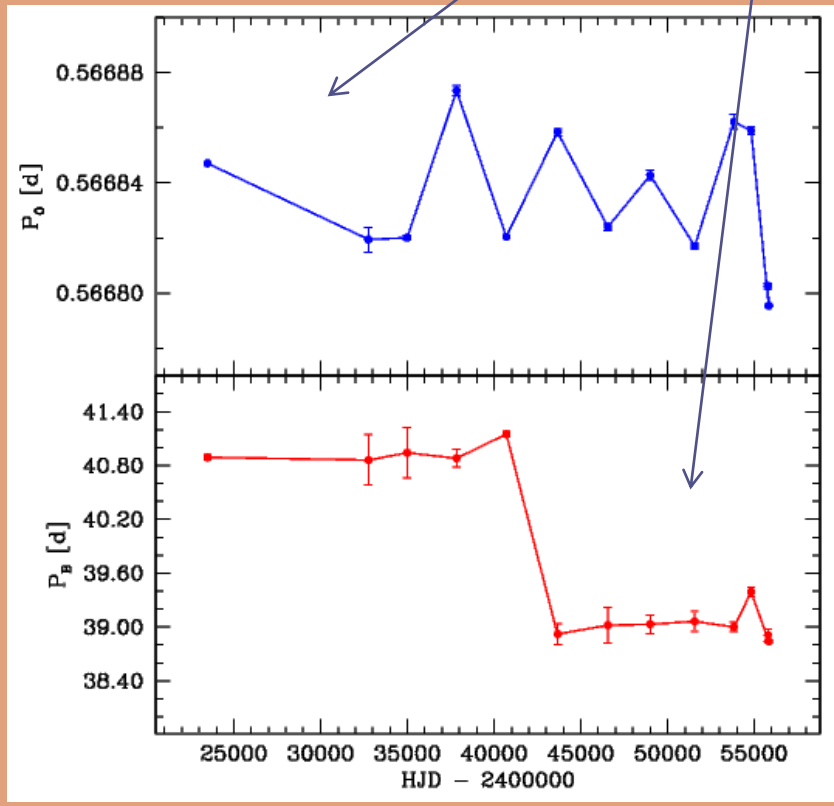
HJD Max = 241 4921.7746 + 0.566 835 616 E.



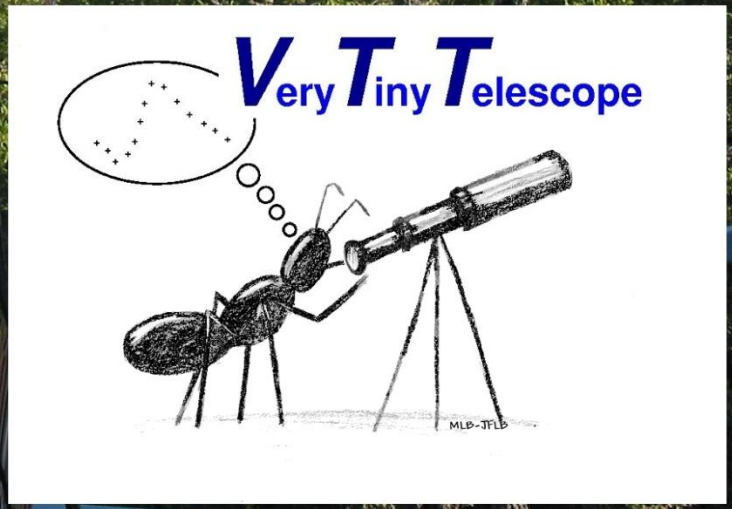
HOW THE BLAZHKO PERIOD HAS CHANGED WHILE THE PULSATION PERIOD ALTERNATED LOW AND HIGH VALUES?



THE **DECOUPLED** VARIATIONS OF THE PULSATION PERIOD P_0 AND OF THE BLAZHKO PERIOD P_B

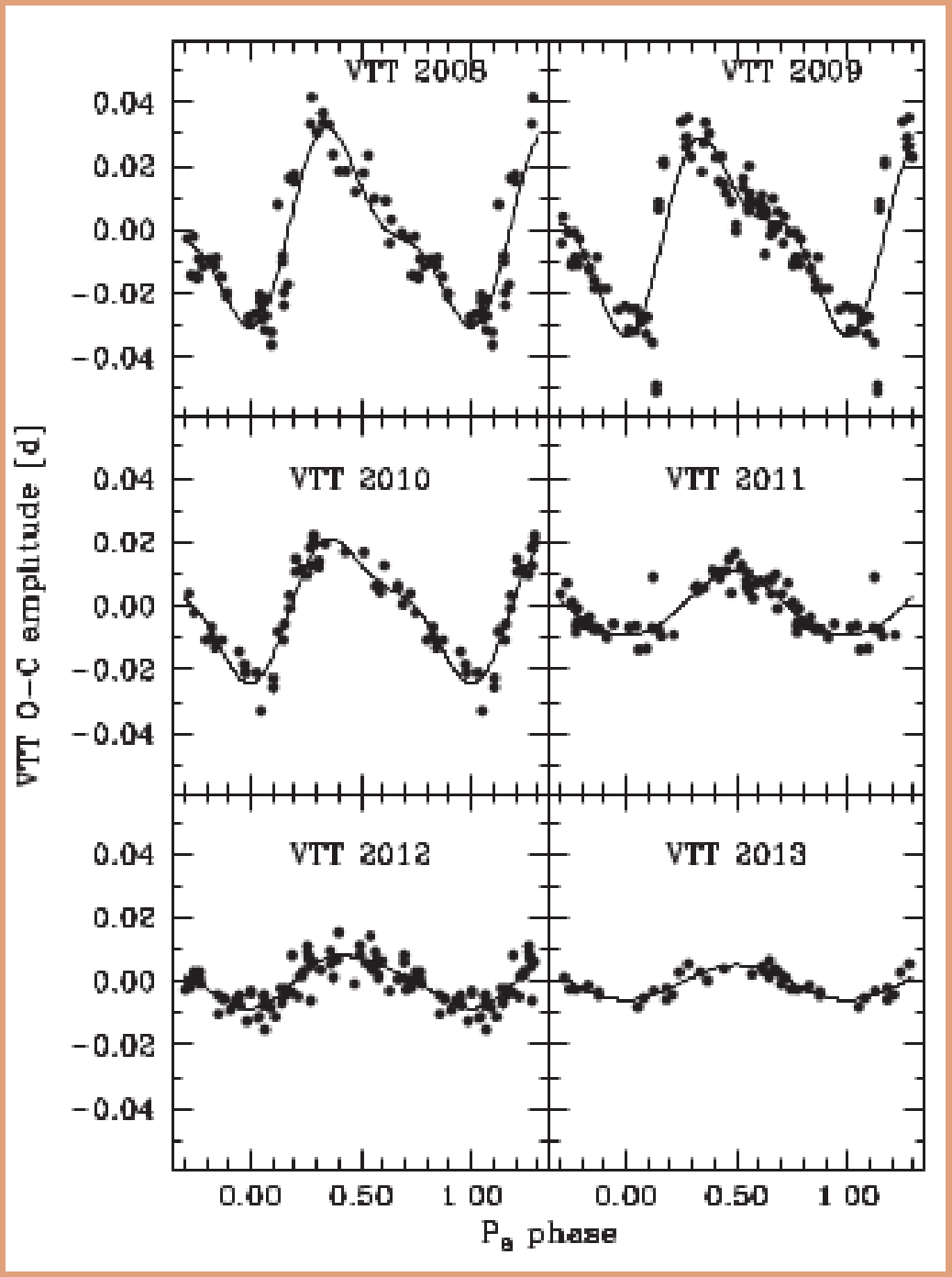


Commercial equatorial mount
CCD camera
Photographic 135-mm focal, f/2.8 lens
Fully transportable instrument

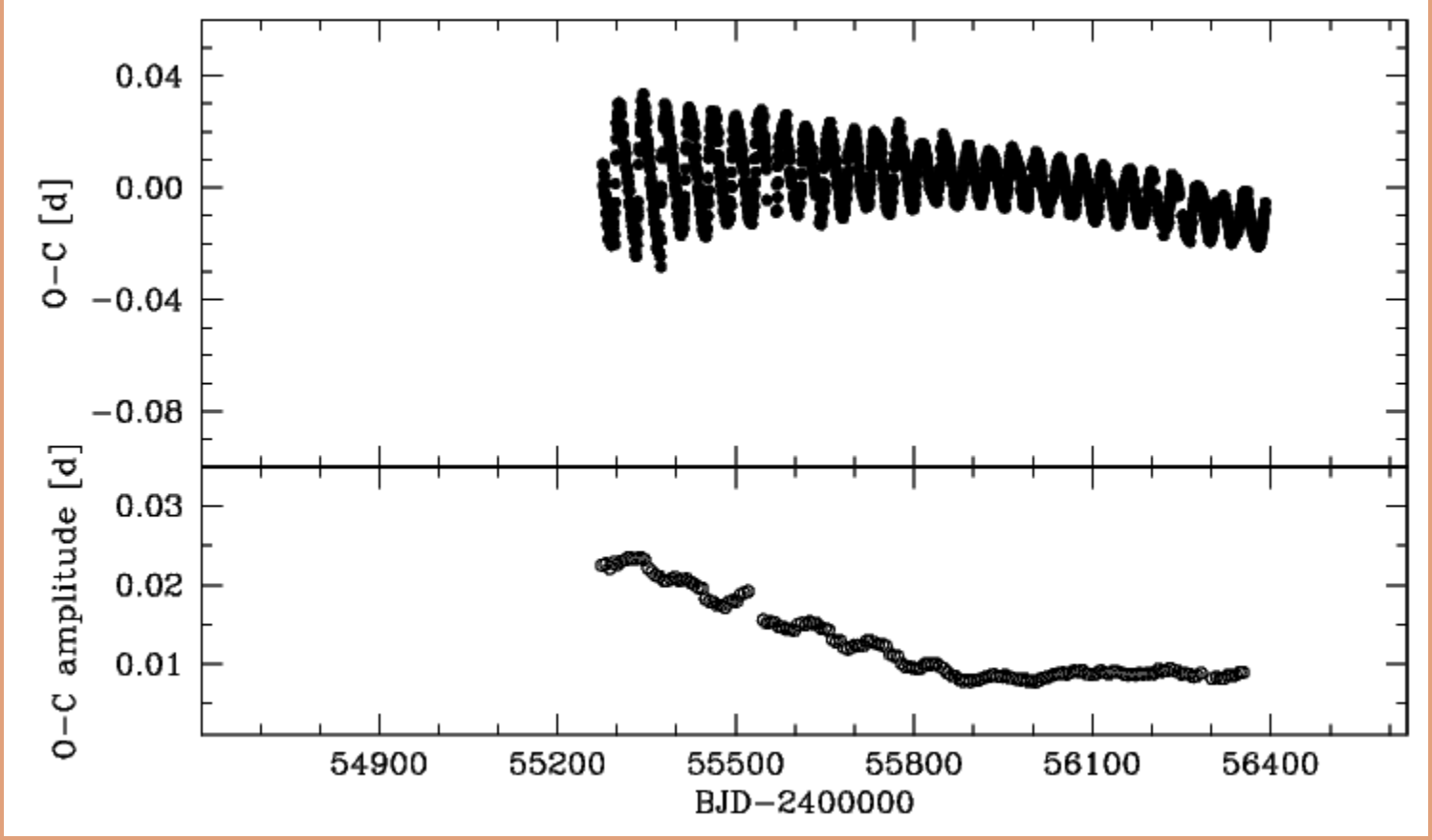


The amplitude of the Blazhko effect is decreasing since 2008 .

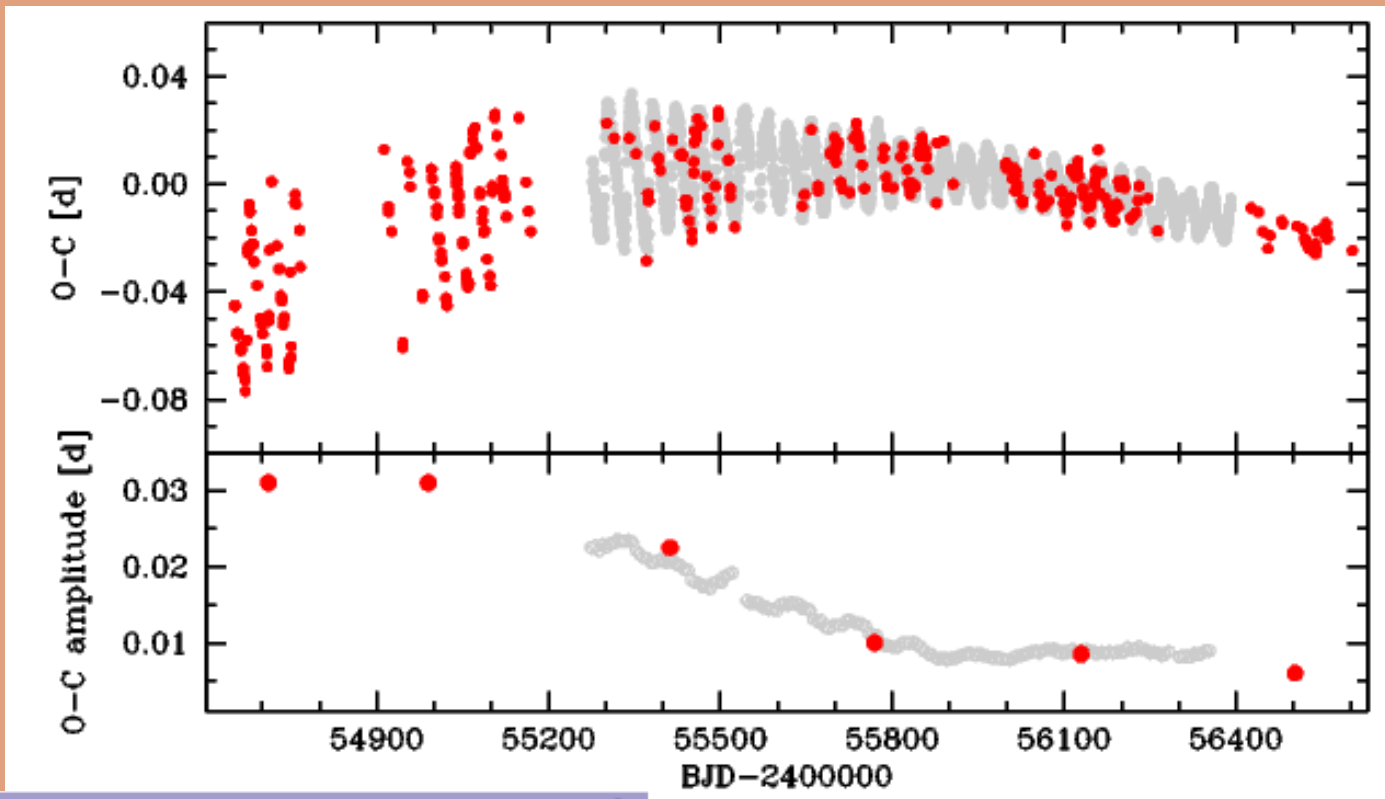
2008	55	0.062 d
2009	78	0.062 d
2010	42	0.045 d
2011	56	0.020 d
2012	75	0.017 d
2013	27	0.012 d



THE BLAZHKO EFFECT OBSERVED WITH KEPLER FROM 2008 TO 2013



Kepler and VTT monitoring



Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

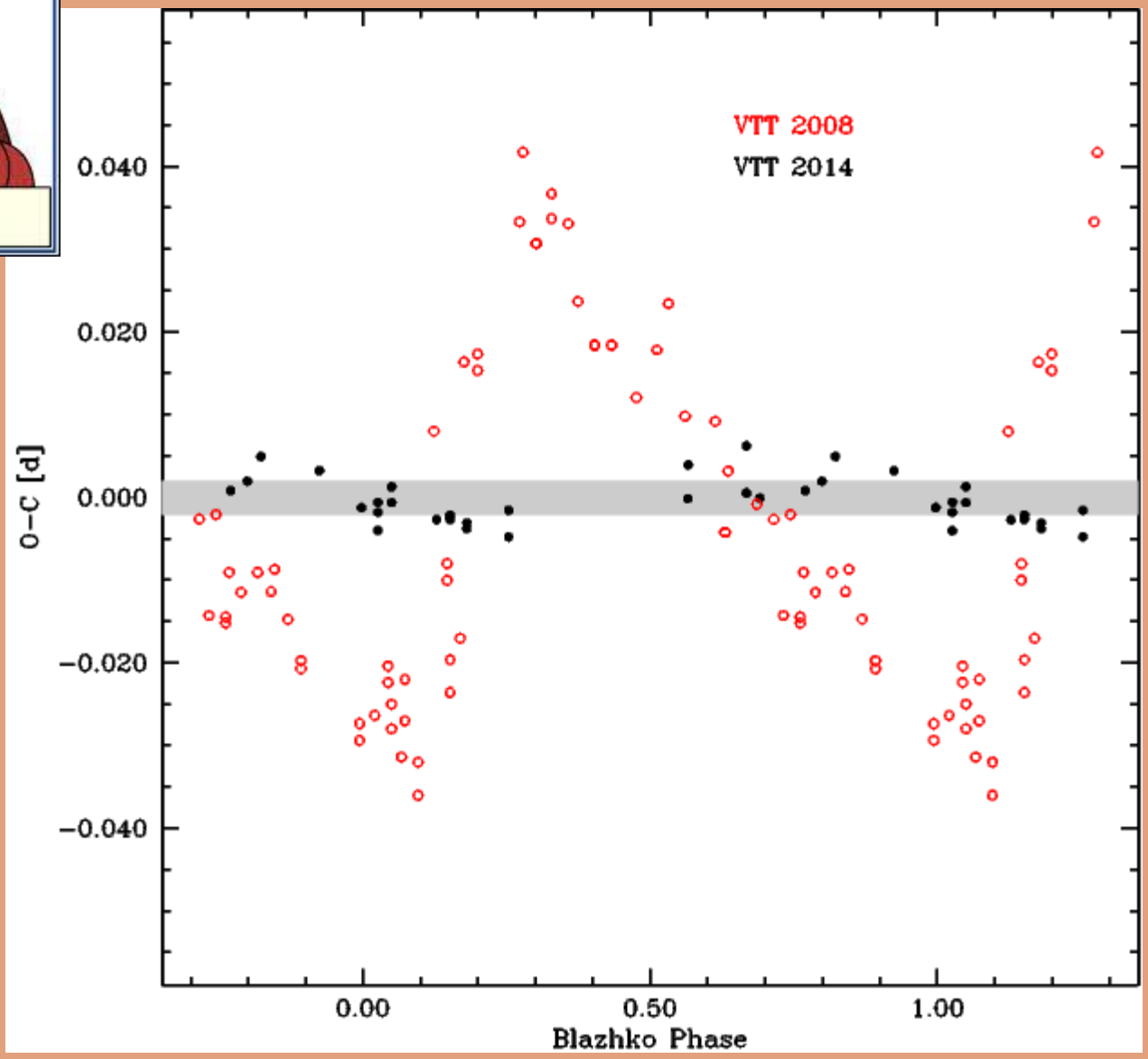
MNRAS **441,** 1435–1443 (2014) doi:10.1093/mnras/stu671

Historical vanishing of the Blazhko effect of RR Lyr from the GEOS and *Kepler* surveys

J. F. Le Borgne,[1,2,3★] E. Poretti,[1,2,3,4] A. Klotz,[1,2,3] E. Denoux,[3] H. A. Smith,[5] K. Kolenberg,[6,7] R. Szabó,[8] S. Bryson,[9] M. Audejean,[10] C. Buil,[11] J. Caron,[12] E. Conseil,[13] L. Corp,[3,14] C. Drillaud,[13] T. de France,[14] K. Graham,[14] K. Hirosawa,[15] A. N. Klotz,[3] F. Kugel,[12] D. Loughney,[16] K. Menzies,[14] M. Rodríguez[17] and P. M. Ruscitti[18]

[1] *Université de Toulouse, UPS-OMP, IRAP, Toulouse, France*
[2] *CNRS, IRAP, 14, avenue Edouard Belin, F-31400 Toulouse, France*
[3] *Groupe Européen d'Observations Stellaires (GEOS), 23 Parc de Levesville, F-28300 Bailleau l'Evêque, France*
[4] *INAF-Osservatorio Astronomico di Brera, Via E. Bianchi 46, I-23807, Merate (LC), Italy*

AT THE MOMENT, RR Lyr IS NOT A BLAZHKO STAR



±1σ

RR Lyr IN 2014

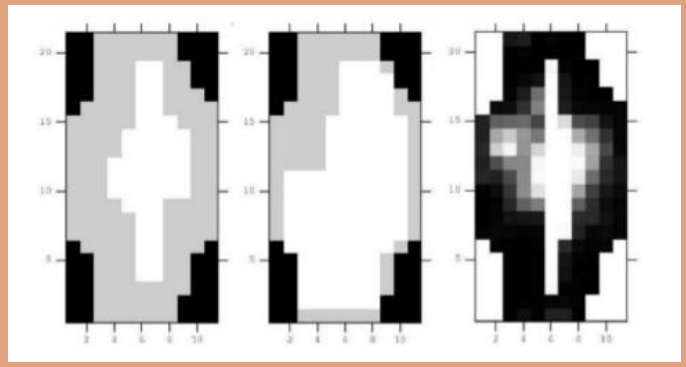
Period and light curve fluctuations of the Kepler Cepheid V1154 Cyg

A. Derekas, Gy. M. Szabo, L. Berdnikov, R. Szabo, R. Smolec, L. L. Kiss, L. Szabados, M. Chadid, N. R. Evans, K. Kinemuchi, J. M. Nemec, S. E. Seade [

Monthly Notices of the Royal Astronomical Society (Impact Factor: 5.52). 07/2012; 425(2).
DOI: 10.1111/j.1365-2966.2012.21538.x
Source: arXiv

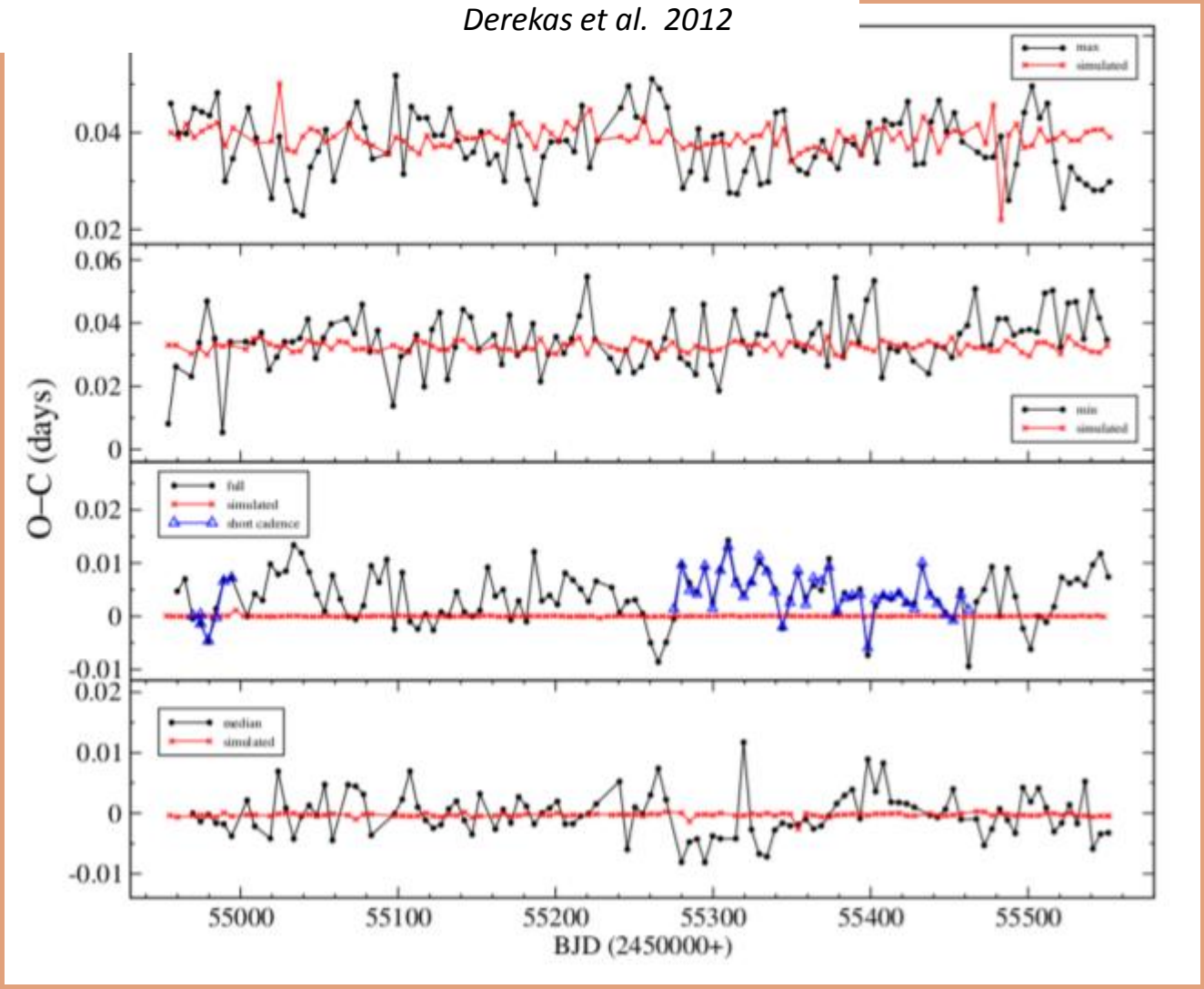
ABSTRACT We present a detailed period analysis of the bright Cepheid-type variable star V1154 Cygni (V =9.1 mag, P~4.9 d) based on almost 600 days of continuous observations by the Kepler space telescope. The data reveal significant [

V1154 Cyg V=9.1 P=4.925 d
Observed with *Kepler* for almost 600 d, i.e., 120 cycles
Heavily saturated, hence elongated aperture was applied *(pixel photometry)*



Cycle-to-cycle fluctuations in the pulsation period.
Cycle length shows a scatter of 0.015-0.02 d over the 120 cycles.
Slight correlation between Fourier parameters and O-C values,
suggesting instability of the light curve.

Derekas et al. 2012



A&A 563, L4 (2014)
DOI: 10.1051/0004-6361/201423444

Astronomy & Astrophysics

LETTER TO THE EDITOR

Convection, granulation, and period jitter in classical Cepheids

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Received 16 January 2014 / Accepted 31 January 2014

ABSTRACT

Analyses of recent observations of the sole classical Cepheid in the *Kepler* field, V1154 Cygni, found random changes of about 30 min in the pulsation period. These period changes challenge standard theories of pulsation and evolution because the period change is non-secular, and explaining this period jitter is necessary for understanding stellar evolution and the role of Cepheids as precise standard candles. We suggest that convection and convective hot spots can explain the observed period jitter. Convective hot spots alter the

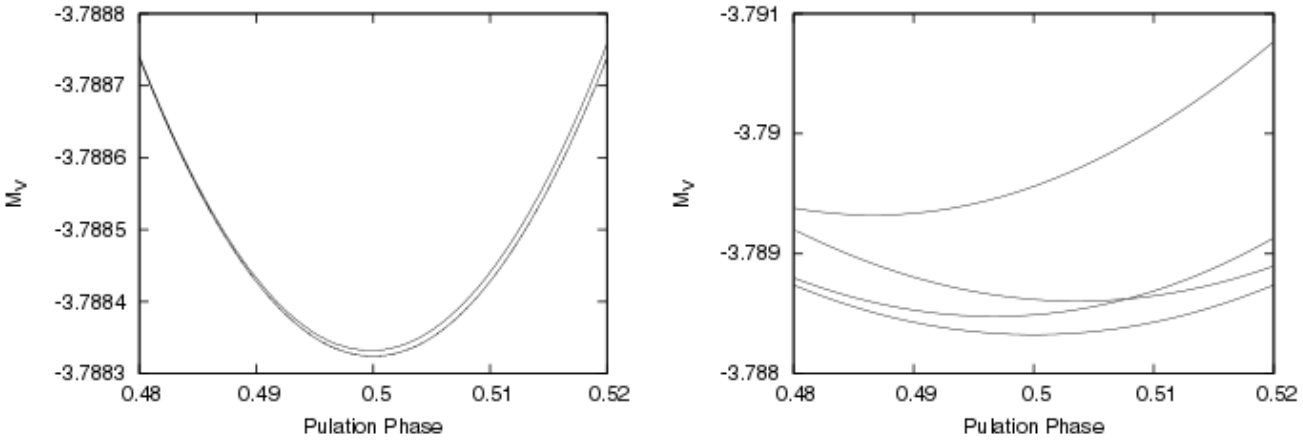
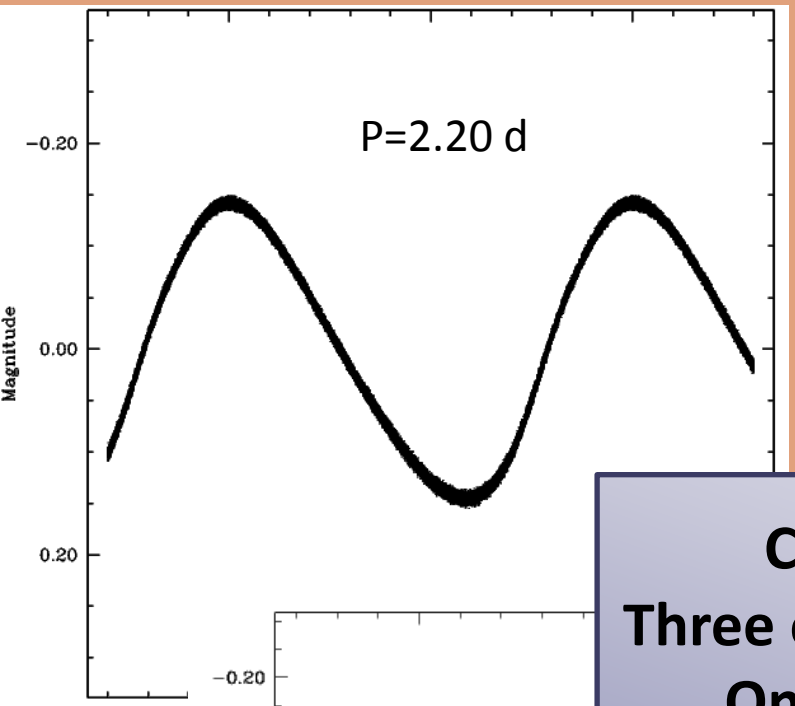
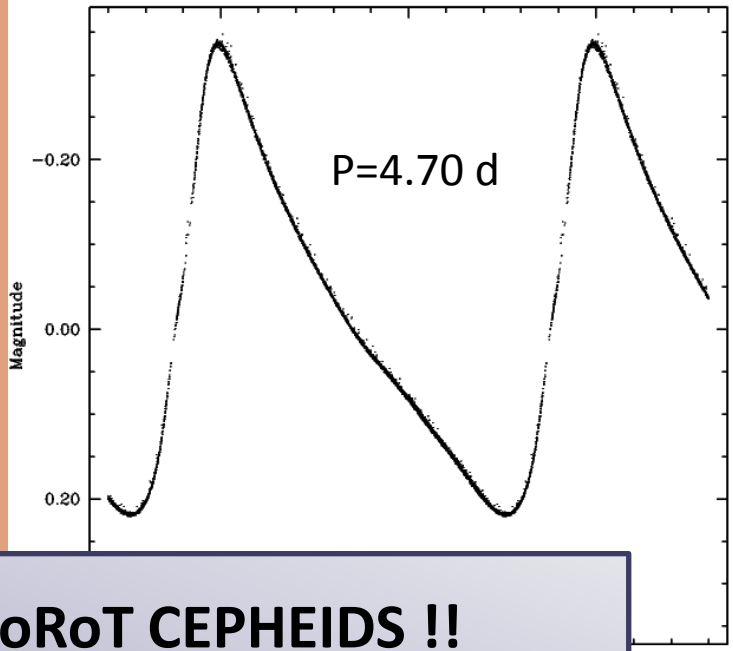
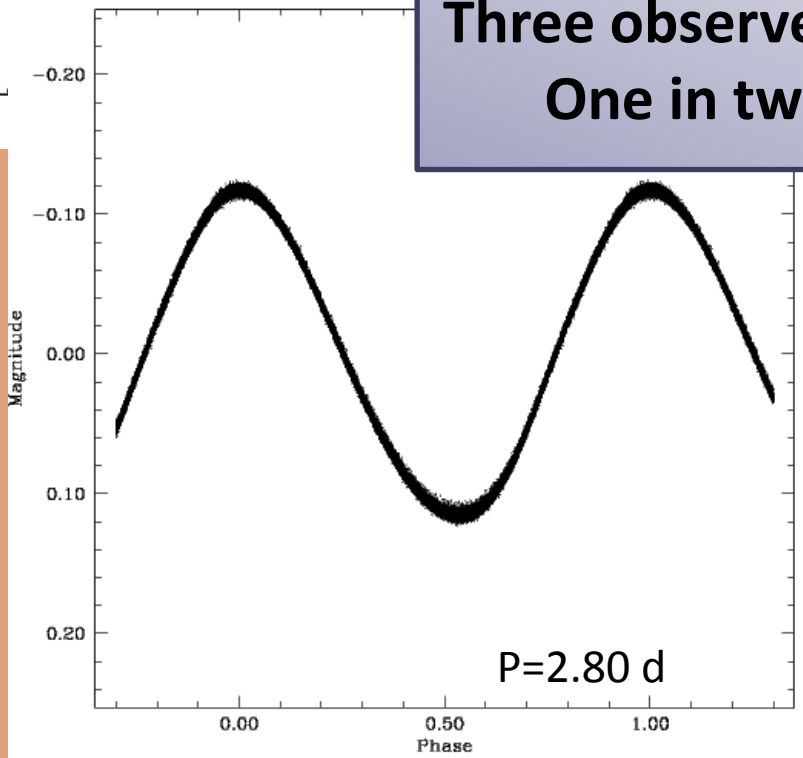


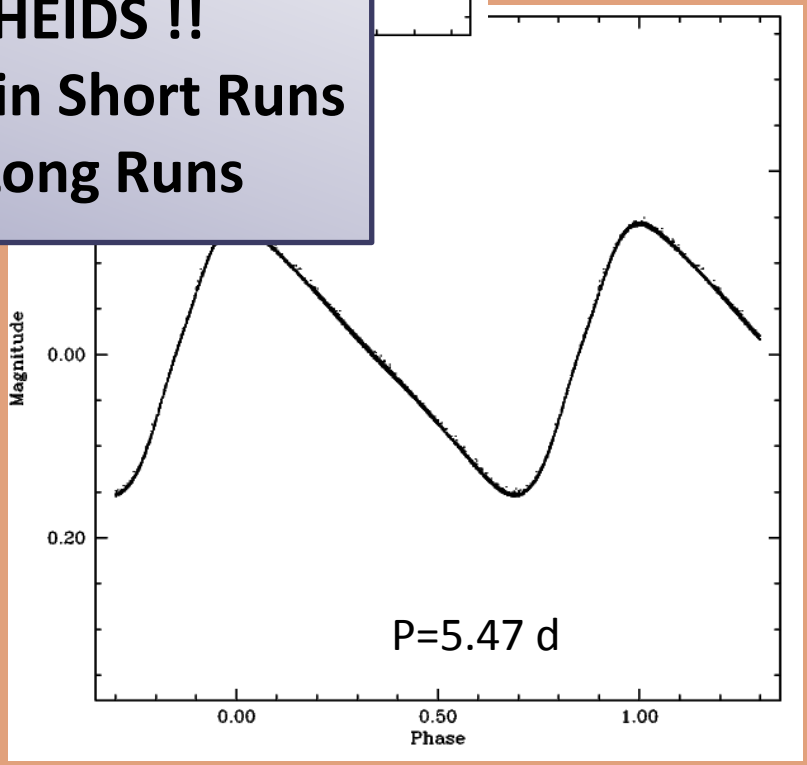
Fig. 4. Variation of a first-overtone Cepheid (or s-Cepheid) light curve due to convective hot spots for two cases near flux minimum. *Left*: the case where spots have an opening angle of 4° and $T_{\rm spot} = 1.03T_{\rm eff}$ and *right* where spots have an opening angle of 7° and $T_{\rm spot} = 1.06T_{\rm eff}$.



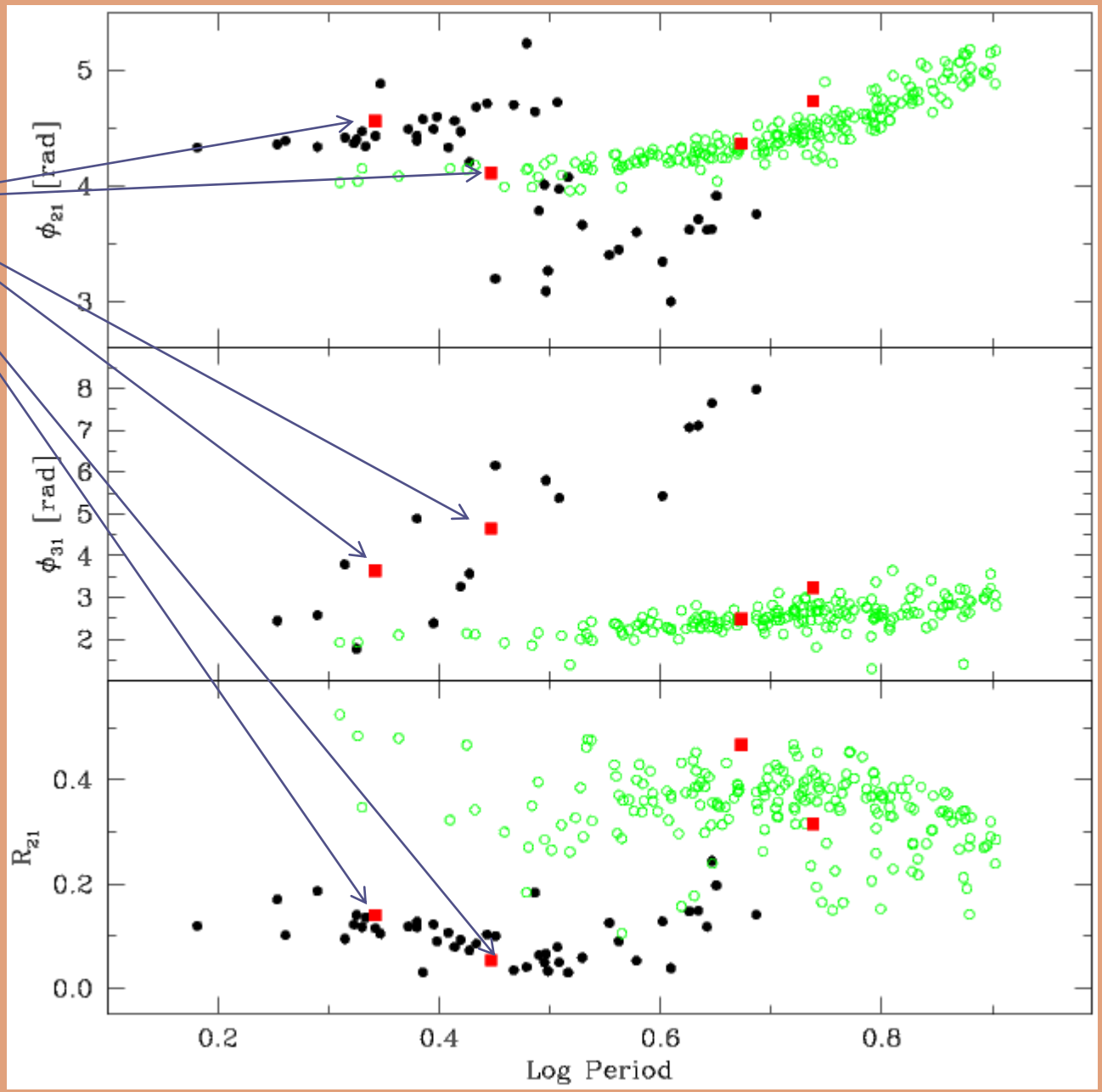


CoRoT CEPHEIDS !!
Three observed in Short Runs
One in two Long Runs

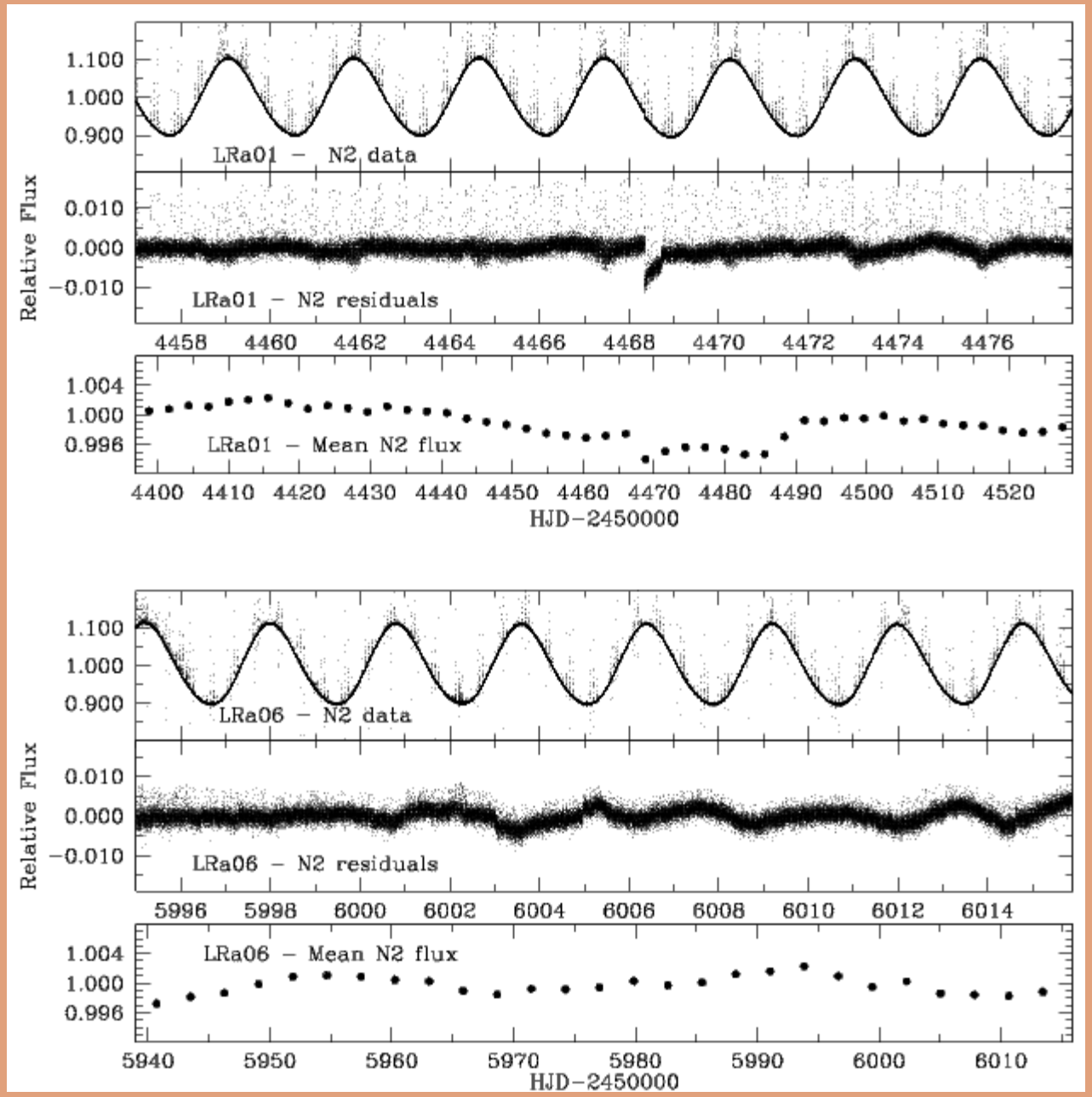


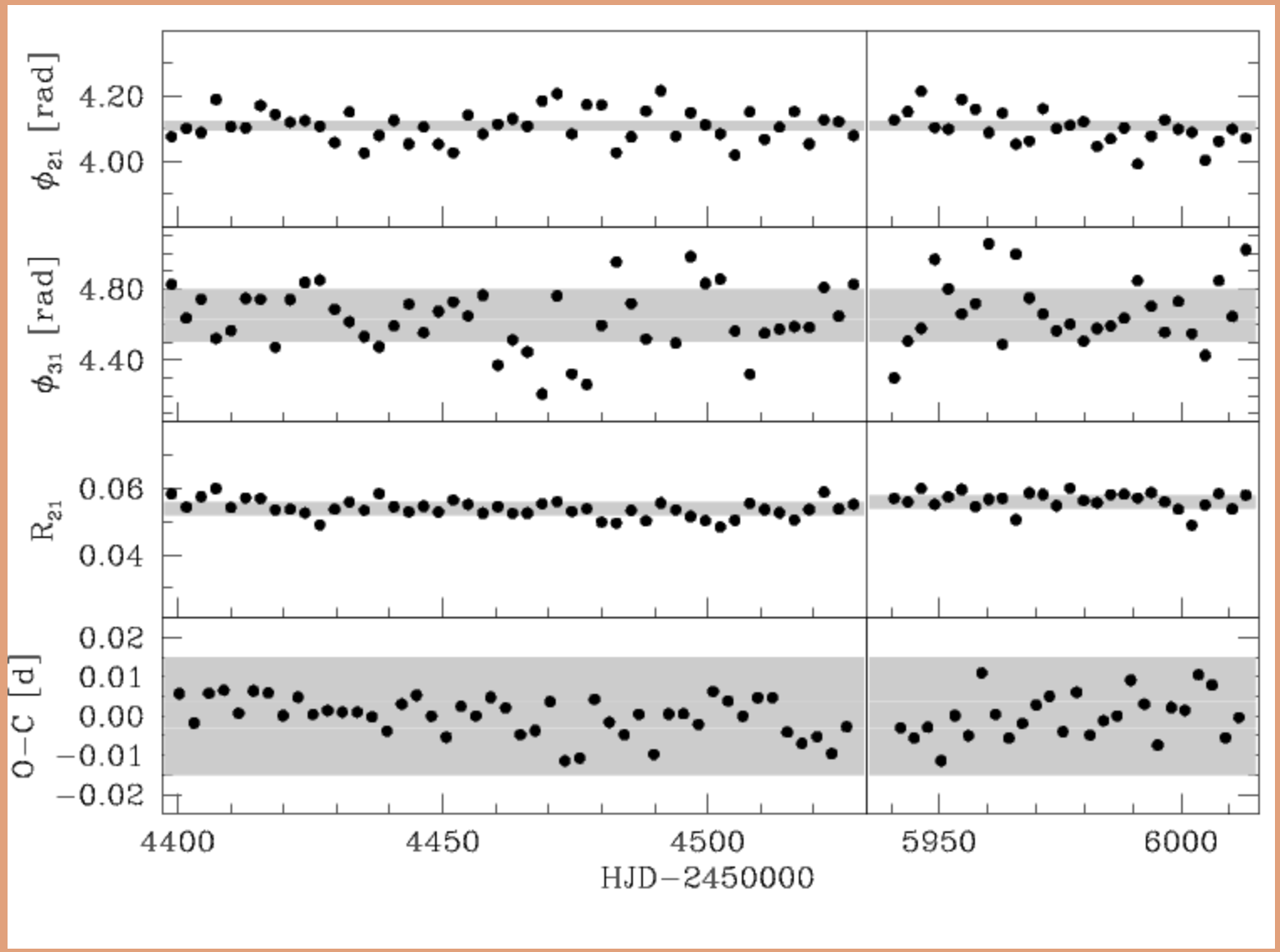


The two short-period Cepheids are FIRST OVERTONE pulsators



The two long-period Cepheids are FUNDAMENTAL pulsators


Relative Flux
1.100
1.000
0.900
LRa01 – N2 data
0.010
0.000
−0.010
LRa01 – N2 residuals
4458 4460 4462 4464 4466 4468 4470 4472 4474 4476
1.004
1.000
0.996
LRa01 – Mean N2 flux
4400 4410 4420 4430 4440 4450 4460 4470 4480 4490 4500 4510 4520
HJD−2450000
Relative Flux
1.100
1.000
0.900
LRa06 – N2 data
0.010
0.000
−0.010
LRa06 – N2 residuals
5996 5998 6000 6002 6004 6006 6008 6010 6012 6014
1.004
1.000
0.996
LRa06 – Mean N2 flux
5940 5950 5960 5970 5980 5990 6000 6010
HJD−2450000



±3σ

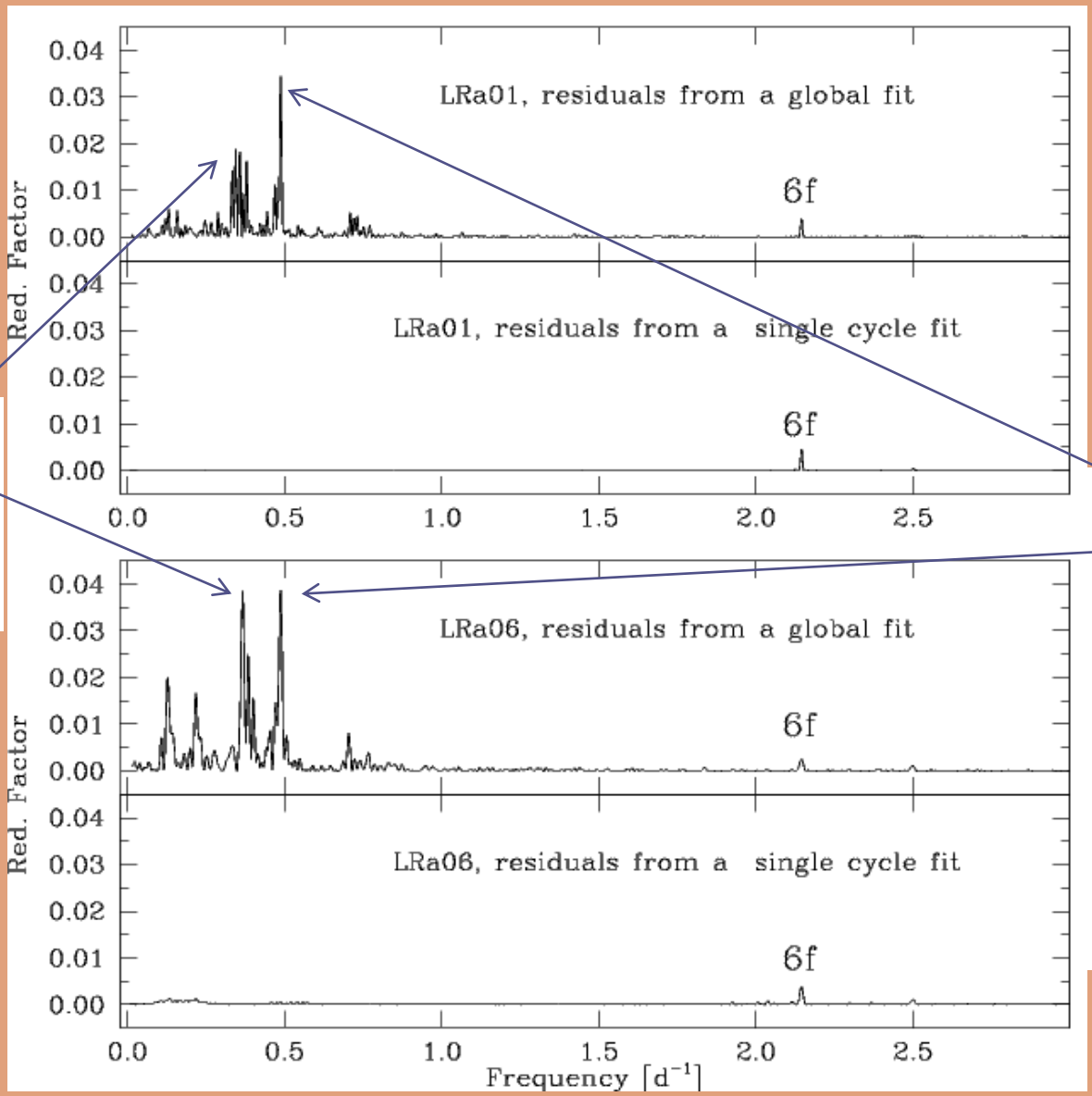
Standard deviation linear ephemeris : 0.005 d

In the space revolution the CEPHEIDS seems the “conservative party” .

Additional modes in High Amplitude Delta Sct stars.
Additional modes in RR Lyrae stars.

No additional mode in V1154 Cyg …

What about the CoRoT Cepheid observed in two Long Runs ?

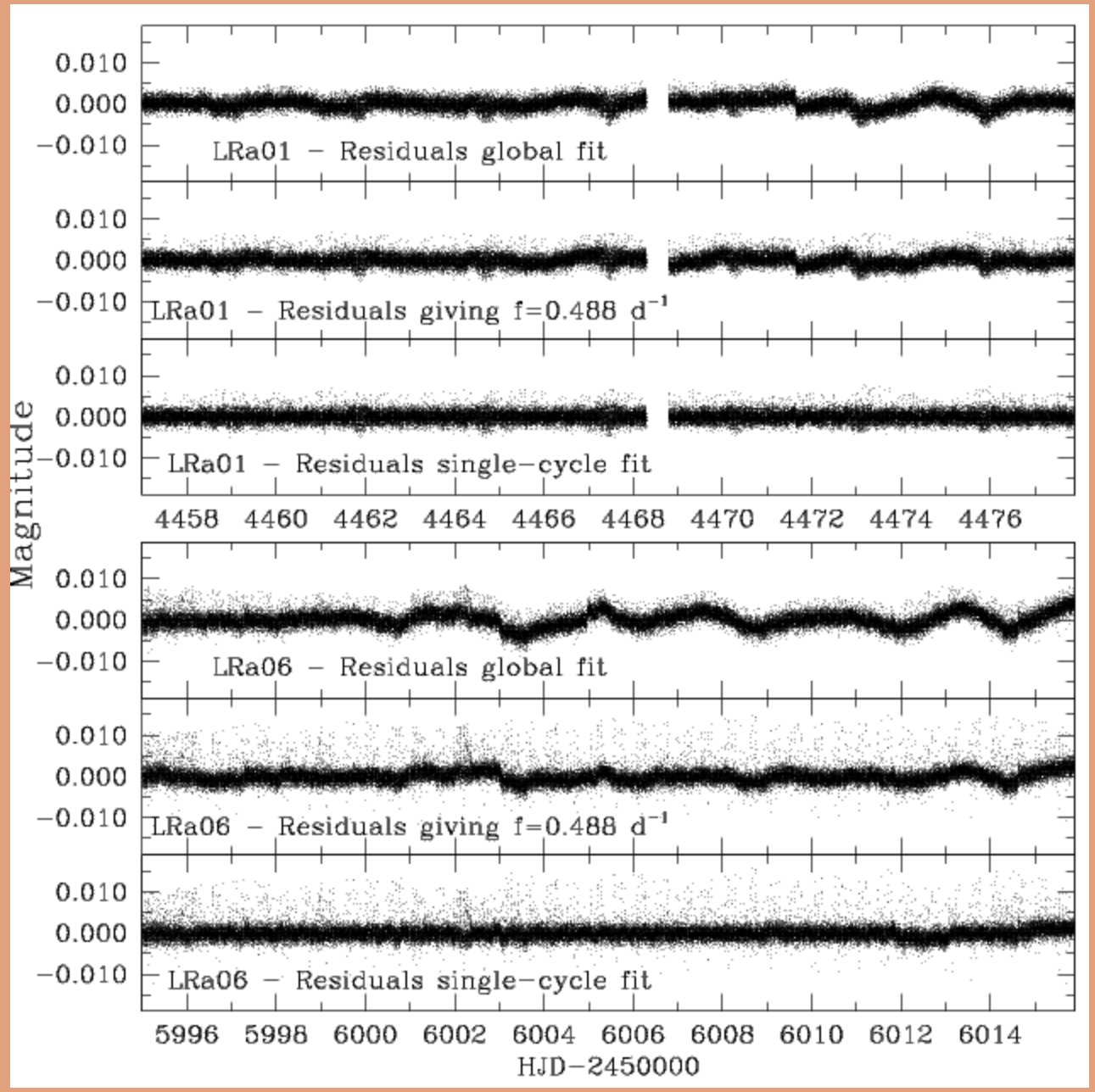


Residual peaks around the main pulsational frequency

A_f=0.10 mag
A_{rp}=0.4 mmag

Additional mode marginally significant?

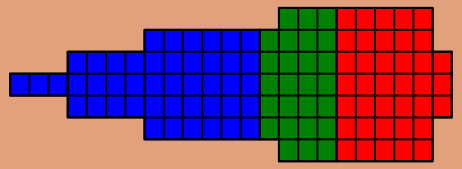
It disappeared when changing the way to compute residuals

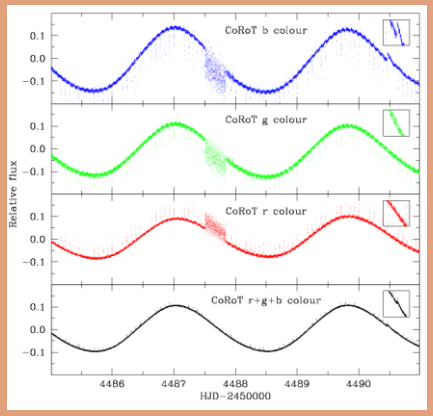

Magnitude
0.010
0.000
−0.010
LRa01 − Residuals global fit
LRa01 − Residuals giving f=0.488 d⁻¹
LRa01 − Residuals single−cycle fit
4458 4460 4462 4464 4466 4468 4470 4472 4474 4476
LRa06 − Residuals global fit
LRa06 − Residuals giving f=0.488 d⁻¹
LRa06 − Residuals single−cycle fit
5996 5998 6000 6002 6004 6006 6008 6010 6012 6014
HJD−2450000

THE CEPHEID HAS BEEN OBSERVED IN THE CHROMATIC MODE

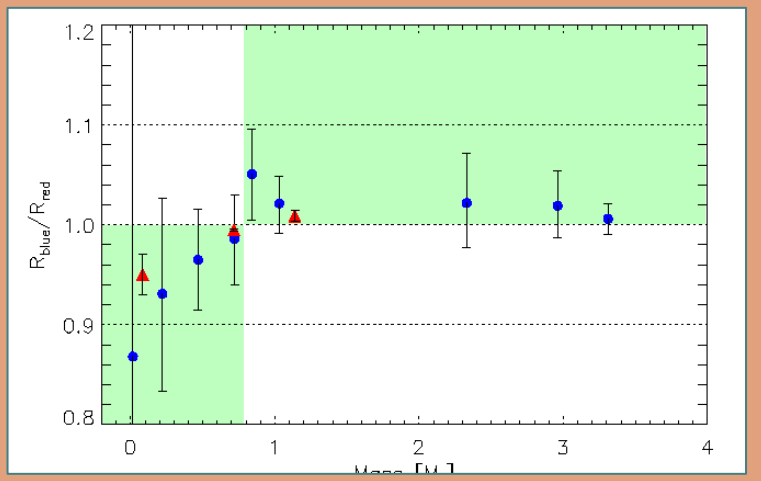
	Blue	Green	Red	White
LRa01	-0.007	-0.003	+0.005	0.000
LRa06	-0.008	-0.005	+0.005	0.000

Phase shifts in function of colour.
Already observed in HADS stars *(Poretti et al. 2010)*





The CoRoT prism is an unique tool for asteroseismic studies from space … *and for exoplanetary science too…*



Borsa & Poretti 2013, MNRAS 428, 891

SUMMARY AND CONCLUSIONS

The pulsational period of **RR Lyr** alternates “high” value and “low” values since 1945.
The Blazhko period suddenly diminished from 40.8 d to 39.0 d in 1975.
The variations of the two periods are decoupled.

➡ CONSTRAINT FOR THE BLAZHKO MECHANISM.

(Le Borgne, Poretti, Klotz et al. 2014)

The Blazhko effect is vanishing, amplitude below 0.005 d.

➡ RR LYR IS CURRENTLY NOT A BLAZHKO STAR, IS IT SLEEPING?
VTTs WILL FOLLOW ITS “WAKING UP”.

Period jitter (up to 0.02 d) was observed in the *Kepler* data of the **Cepheid** V1154 Cyg *(Derekas et al. 2012).*

Random hot spots perturb Cepheid light curves. Convection as a new ingredient to model Cepheids *(Neilson & Ignace 2014).*

Four new CoRoT Cepheids. Period jitter is observed, but up to 0.010 d only.
No clear additional mode. Just a weak signature in the power spectra, probably due to instrumental problems.